DUAL HEMISPHERE ANTENNA

Background of the Invention

The present invention is directed to the field of wireless networking, with particular applicability to rollouts in which there is a large quantity of wireless traffic in a given operational area. It is becoming increasingly common to implement wireless local area networks (WLANs) in addition to or in place of traditional LANs. In a traditional LAN, each client device, e.g. a personal computer etc., requires a physical, hard-wired connection to the network. However, with a WLAN, each client device includes a wireless capability (such as an insertable, embedded card or fully integrated capability) for wirelessly communicating with the network via an access point (AP) that includes an antenna, a transceiver and a hard-wired connection to the network. In this way, users may carry their hand-held devices and laptop computers within a physical area and still maintain a network connection.

However, in "crowded" enterprise rollouts, it can be difficult for a large number of users to simultaneously access the network due to the contention-based protocol used. Accordingly, it has been contemplated that multiple wireless channels can be used for allowing user access. Three non-overlapping channels have been allocated in the 2.4 GHz band, and eleven channels in the 5 GHz band. Using multiple available channels, an AP may be implemented in a single-package topology that enables simultaneous transmission and reception on nearby frequency channels at the same interval in time. A problem inherent with such a topology is a high degree of self-interference between signals on adjacent channels, resulting in poor quality of service. It is thus desirable to provide signal isolation between each transceiver in the AP. Depending on

the tranceiver architecture, there will be an additional antenna-to-antenna isolation requirement that must be met to achieve the overall required signal isolation.

A special problem arises when a multiplicity of antenna elements used to support a single unit, multichannel AP are in close proximity to each other and whose element-to-element isolation is low. The overall requirement is to cover a large (omnidirectional) area with all of the AP channels, either in concert or sectorially. Absorber materials are known for providing antenna isolation, but these materials are expensive, bulky, and otherwise unsuitable as the sole method for achieving the required isolation. Physical separation between the antennas is also a solution, however this would lead to a product that could not be neatly integrated into a single reasonably sized housing. This problem can be also addressed by the use of "smart" antennas, in which the antenna can be "steered" toward a particular client or group of clients to send and receive signals and yet maintain high isolation from other steered beams. Directional antennas with high front-to-back ratios (F/B ratio) can also be used in some applications, such as when a geometrically isolated area must be covered. However, a special case arises when a two channel system is desired. These might be two channels in the 2.4 GHz band or two channels in the 5 GHz band. In these situations, one desires a hemispherical radiation pattern so that the coverage area can be divided into two sectors. The isolation must still be high to allow simultaneous operation of those two transceivers. A novel solution to this special problem is disclosed herein.

Summary of the Invention

The difficulties and drawbacks of previous-type implementations are addressed by the presently-disclosed embodiments in which a wireless device is disclosed, including an antenna system comprising one or more antenna elements for sending and receiving a wireless signal.

One or more conductive members are included, having an edge displaced from and substantially directed toward at least one antenna element, and cooperating therewith to establish a hemispherical beam pattern for a wireless signal.

As will be realized, the invention is capable of other and different embodiments and its several details are capable of modifications in various respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative and not restrictive.

Brief Description of the Drawings

Figs. 1A, 1B and 1C respectively show various embodiments of the present antenna system.

Fig. 2 shows the operation of a wireless access point implemented with the present antenna system.

Figs 3A and 3B generally depict antenna gain patterns obtainable with the present antenna system.

Figs. 4A, 4B, 4C, 4D and 4E show various alternate embodiments of a conductive fin as used with the present antenna system.

Figs. 5A, 5B and 5C are diagrams showing various degrees of signal isolation between each antenna in a dual antenna embodiment.

Fig 6 is a diagram showing the antenna gain pattern for a single antenna in a present embodiment.

Detailed Description of the Invention

Particular reference is now made to the figures, where it is understood that like reference numbers refer to like elements. As shown in Fig. 1A, the present antenna system 10 includes one or more antenna elements 12 for sending and receiving a wireless signal. One or more conductive members 14 are provided, preferably in the form of metallic sheets or fins, having an edge 16 displaced from the antenna element 12. The edge 16 is substantially directed toward the antenna element 12. The antenna system 10 is a cooperative component of a radio transceiver including a plurality of radio components for processing a wireless signal, as will be set forth in detail below. It has been observed that a conductive member 14 and an antenna oriented in this manner cooperate in such a way as to establish a hemispherical beam pattern, as will also be set forth in greater detail below.

Applicants have discovered that metallic fins 14 configured with antennas 12 in the disclosed manner simultaneously provide signal isolation and a dual hemispherical radiation pattern for each antenna 12. It has been contemplated that the metallic fins 14 can be formed of brass having a thickness of about 5 mils and dimensions of 3 inches x 4 inches at a nominal operating frequency of 2.4 GHz. Appropriate scaling is required for operation at other frequencies, inversely proportional to frequency. It is of course appreciated that any suitable

metal or other conductor could be substituted for brass. The antennas 12 are preferably dipoles selected to provide a wide bandwidth with a small aperture and a suitable elemental radiation pattern.

In an exemplary embodiment shown in Fig. 1B, two dipole antennas 12 are used with a plurality of metallic fins 14 placed between the antennas, lying in the same plane as the antennas 12. A ground plane 18 may be optionally be included. In this exemplary embodiment, a sandwich module 20 is provided for providing a further level of antenna isolation. The sandwich module 20 includes metal plates 22, preferably formed of brass, which substantially face the metal fins 14, preferably at a perpendicular angle. These plates 22 are preferably electrically separated from the fins 14, though they may optionally be in electrical contact. The sandwich module 20 also preferably includes a separation material 24, which is preferably an RF isolating foam such as AN-77 or another suitable type of material.

Various permutations of element size and orientation were discovered that result in varying degrees of isolation, as will be shown below in the discussion of the other embodiments. For example, as shown in Fig. 1C, the sandwich may alternatively be omitted; an embodiment in which no metal plates 22 or isolating foam is employed. In a further alternate embodiment, brass plates 22 alone may also be employed, without the isolating foam 24. In a further alternate embodiment, brass plates 22 may also be employed, with the isolating foam 24. Table 1 lists various isolation cases of selected permutations of the sandwich module.

Table 1 Isolation vs. Sandwich

Quantity of Conductive Members 14	Composition of Sandwich Module 20	Isolation (dB)
None	Air	22
Two	Air	45
Two	Brass Sheets 22	51
Two	Brass Sheets 22 and AN-77 24	59

Because a dipole is an omni-directional radiating element, the isolation between two antennas is poor without any additional isolation element. For example, at one wavelength of separation (4.8" at 2450 MHz), 2 dipoles have only 22 dB of isolation. However, with the presence of two of the fins 14, an isolation of greater than 45 dB is obtained, as shown in Fig. 5A. However, with the presence of two fins 14 and a separation material 24 (brass sheets), an isolation of greater than 51 dB is obtained, as shown in Fig. 5B. However, with the presence of two fins 14 and a separation material 24 (brass sheets and isolating foam), an isolation greater than 59 dB is obtained, as shown in Fig 5C. The embodiment of Fig. 1B provides signal isolation between the two dipole antennas of greater than 51 dB in the 2.4 GHz WLAN band, which is a standard band from 2412 to 2484 MHz, as shown in Fig. 5B.

Fig. 6 illustrates the H-Plane radiation pattern of one hemisphere in the embodiment of Fig. 1B. A 3 dB beamwidth is measured in the H-Plane of about 186 degrees, which substantially demonstrates the desired characteristic of a hemispherical coverage antenna element. The resultant pattern demonstrates excellent symmetry and minimal variation over the frequencies of interest. A hemispherical radiation pattern results for each antenna element, thereby providing good radiated power at the points where the channels will overlap, thus minimizing pattern-to-pattern signal minima (or scalloping).

The hemispheric pattern and resulting high isolation obtained by the present arrangement enables a dual hemispherical antenna system in which two antenna elements 12a, 12b of Fig. 2 can be used to cooperate with the conductive member 14. In this way, as especially shown in Fig. 2, each antenna element 12a, 12b can communicate simultaneously on partially-interfering channels within the same wireless band. As shown in the Fig. 2, each antenna element 12a, 12b cooperates with one of a plurality of radio transceivers 30. Each transceiver includes a plurality of respective radio components 32a, 32b for processing a wireless signal. In this manner, one antenna 12a e.g. can transmit while the other antenna 12b receives on a different channel in the same band. As shown in Fig. 3A, each antenna 12a, and 12b would produce its own respective isolated beam pattern 34a, 34b such that a dual hemispheric beam pattern would ideally result with no coupling. However, in practice, as shown in Fig. 3B, the respective beam patterns 34a, 34b are closer to about 186 degrees, and so there is some overlap between the coverage areas of the antenna elements 12a, 12b. Though a minor amount of signal coupling may result in this overlap region, this is nevertheless a satisfactory outcome since it insures a full 360 degree field of coverage for wireless clients.

The benefits of the present system can be realized in a variety of configurations. In one embodiment, for example, a single antenna element 12 can be configured to cooperate with the conductive member 14. In a preferred embodiment, as particularly shown in Figs. 1A, 1B, 1C inter alia, a pair of antenna elements 12 are provided, disposed respectively at opposite ends of the at least one conductive member, and cooperating therewith to establish a respective pair of hemispherical beam patterns.

As is shown in Fig. 4A, a plurality of antenna elements 12a, 12b can be provided, disposed respectively along the periphery the conductive member 14. These antenna elements

12 and the conductive member cooperate therewith to establish a respective plurality of hemispherical beam patterns. A portion of antenna elements 12a, 12b can be adapted to operate over one wireless frequency band, and another portion of antenna elements 12a, 12b can be adapted to operate over a second wireless frequency band. For example, in the four-antenna embodiment shown in Fig. 4A, the antenna elements 12a can be used to operate over the 2.4 GHz band and the other antenna elements 12b can operate over the 5 GHz wireless band. It should be understood that a peripheral arrangement is not limited to four antennas around a square conductive member. Any polygonal arrangement could be contemplated, such as hexagonal or octagonal, without departing from the invention. The isolation in these embodiments will differ from that example provided for the two-element configuration, depending upon the geometrical topology.

Another embodiment of the present antenna system 10 is shown in Fig 4B. A plurality of conductive members 14a, 14b can be provided where each conductive member 14a, 14b is associated with one or more antenna elements 12a, 12b. The conductive members 14a, 14b are preferably discrete fins, oriented at a substantially perpendicular angle, where respective fins 14a are coplanar, and respective other fins 14b are also coplanar. Each conductive member 14a, 14b is preferably associated with a respective pair of antenna elements 12a, 12b, disposed at respective opposite ends of their respective conductive member 14a, 14b. The respective fins 14a, 14b are preferably not connected, intersected members, but these can be made connected and intersecting without departing from the invention. Also, further to the embodiment of Fig. 1B, this embodiment may be configured with a sandwich module, in which the metal plates for one set of antennas 12a form the fins 14b for the respective other set of antennas 14b.

Preferably, the pair of antenna elements 12a associated with a first conductive member 14a is adapted to operate on a first wireless frequency band. The pair of antenna elements 12b associated with a second conductive member 14b is adapted to operate on a second wireless frequency band. The respective wireless frequency bands can be 2.4 GHz and 5 GHz wireless bands. However, it should be understood that this embodiment is not limited to only two bands. The antenna system 10 can include a number of conductive members arranged in a "star" type configuration, with respective pairs of antenna elements, all without departing from the invention.

In the preferred embodiment, the conductive member 14 is two substantially coplanar elements that are coplanar with the one or more antenna elements 12. However, as shown in Fig. 4c, a plurality of planar elements 14 can be provided, substantially coplanar with the antenna element 12. Alternatively, the conductive member 14 can be a substantially contoured member. As shown in Fig. 4D, the substantially contoured conductive member 14 can be an angled member having a vertex edge 40 substantially directed toward the antenna element 12. In general, it has been observed that the isolation and hemispheric beam pattern are obtained by having a sharply defined edge 16 directed toward the antenna element 12. Also, the edge 16 should be parallel with the dipole antenna element 12. In the preferred embodiment, as indicated above, the antenna element 12 is a dipole antenna and the conductive member 14 is one or more discrete components. However, in an alternate embodiment shown in Fig. 4E, one or more antenna elements 12 and conductive members 14 can be formed on a single piece of circuit board material 42, and manufactured thereon by typical processes of circuit board manufacture, e.g. acid etching or machining, etc. In any event, it has been observed that the desirable isolation and

beam pattern were obtained in embodiments where the antenna element 12 is shorter that the respective edge 16 of the conductive member 14.

The present dual hemisphere antenna arrangement provides a 180-degree sector antenna implementation with low "scalloping", greater than the gain of an omnidirectional antenna and at least 51 dB of isolation (so as to keep the transmit signal out of the receiver alternate channel). Also, the materials used in the present embodiments are inexpensive and the topology would be straightforward to manufacture. Thus, the present system achieves superior results over previous-type systems with an inexpensive solution that simultaneously has 180° beamwidth and 51 dB of isolation. This is an improvement over known-type sectorized antennas, such as are common in the cellular world, that rely on physical separation, polarization diversity, and expensive diplexers to achieve isolation.

The present conductive member 14 is essentially a reflector screen that provides a high degree of isolation between two dipole antennas, simultaneously yielding a hemispherical radiation pattern in the H-plane. The solution does not require the use of traditional frequency selective surfaces where the benefit might be only 6 dB per octave per surface to get the 51 dB+ isolation. Similarly, the present invention does not require polarization screens since the two antenna elements 12 operate at the same polarization, and a slant polarization would result in a 4 dB penalty of forward gain against the link budget. Finally, the present results are obtained in a compact package which would be very desireable from a consumer marketing standpoint.

As described hereinabove, the present invention solves many problems associated with previous type systems. However, it will be appreciated that various changes in the details, materials and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention may be made by those skilled in the area within the principle

and scope of the invention will be expressed in the appended claims.